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Very Young Children's Development in Moviemaking

John Matthews

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In this study, I gave a group of six to eight very young Chinese Singaporean children (between 2 and 4 years of age) three identical digital video cameras, plus tripods, and tracked their development in moviemaking over a 2-year period. The children were allowed to explore the cameras freely, though the investigators offered advice and support as and when necessary. Before this study, I had made detailed longitudinal studies of British and Asian children's representational development in pencil-and-paper technologies. I was interested to find out whether insertion of a different, electronic moviemaking medium into development would change developmental histories fundamentally or whether it was possible to discern key patterns of development and developmental principles, despite change in media. Previous studies suggest that, by changing the medium, the new tools of representation would reconfigure development, emphasizing aspects of representational thinking less apparent in other media. For example, physical paint redirects the child's development of linear shape, but key structures persist despite a new interest in color and texture. Golomb's (1974, 1992, 1993) work also shows that giving young draftspersons clay, instead of crayons or pencils, also causes interesting developmental variations but that key patterns of action still persist.

The child's development in her or his use of digital video cameras is one that has not yet been recorded. There are no histories or "stages of development" in children's moviemaking. The introduction to very young children of this electronic, digital, and lens medium offers us an opportunity to look closely at the process of development as it happens.

In a nursery and kindergarten school in Singapore, Rebecca Chan and I gave 2- to 4-year-olds digital video cameras (handicams) to see what they would do with them. We traced the development of children's videography over a period of 24 months. With the help and guidance of Linda Matthews, I had already undertaken studies of children's development in visual representation and expression (Matthews, 1984, 1999, 2004). These studies traced the origin and development of children's visual representation in traditional media, focusing special attention on the example of drawing but locating this within a cluster of emergent representational acts.

In these earlier studies, we looked at how children used events, objects, speech, and actions to form early representational and expressive modes. This involved the study of the expressive and representational actions that children perform with anything they can get their hands on—to use Kress's (1997, 2004) apt way of putting it. Hence, we observed children investigating and playing

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with a wide range of materials, including available devices of image making, ranging from fingers trailed in milk to pencil and paper to electronic technologies of expression and representation.

We found that meaning making is a continuum that starts in the baby's earliest actions. Much of this early representation has escaped the notice of researchers. The reason is that emergent representation is embedded in actions that, for many people, look trivial and meaningless. Yet these early, commonplace actions are saturated in meaning and are at the beginning of a continuum in the understanding and use of semiotic systems.

The present research provides a developmental dimension that is missing from much of the recent textually based work on "multiliteracies." I believe that it is not possible to illuminate children's modes of representation or to understand what drives and guides children's interaction with a range of communicational tools unless one knows something of how their media use fits into a developmental continuum. Only with this understanding will adults be in a position to help development and learning move along.

In the earlier studies, children's drawing was used because it was a stunning example of a developmental process. However, because of definitional problems about the nature of visual representation and the stories accumulated around the construction (and simultaneous marginalization) of something termed *children's art*, it has remained difficult for us to convince some people of the true nature of development in representational thought and of its relationship to learning. This failure of perception has had enormous consequences for education.

My studies of children's development in visual representation and expression reveal children's taking advantage of semiotic opportunities in their use of materials and media (Matthews, 1999, 2003a, 2004a). Developmental movement through an unfolding series of possibilities is driven by deep emotions formed in companionship with an adult caregiver (usually, but not necessarily, the infant's natural mother; Trevarthen, 2003) and guided by a continuum of *attractor systems* (Thelen, Schoner, Scheier, & Smith, 2000; Thelen & Smith, 1998). Attractor systems are configurations of behavior toward which the thinking, feeling infant gravitates. They have a temporary stability but are essentially dynamic, and they change according to the changing interrelationship between infant and environment (Goldfield & Wolff, 2004; Thelen & Smith, 1998). In the present account, attractor systems comprise actions, forms, and relationships in the world to which the child's attention is turned, in an orderly sequence, and become interiorized thought (Piaget, 1951). The way in which these systems shape a developmental trajectory is not determined in advance. These are not internal blueprints predetermining development but are responsive to initial and changing conditions (Matthews, 2003, 2004a; Thelen & Smith, 1998). At the same time, they are biased toward certain developmental directions rather than others (Edelman, 1987).

These systems have to be considered relational rather than absolute or a priori. The children exploit representational and expressive opportunities as they unfold in real space-time. This means that development is neither predestined nor free to go just anywhere.

A careful study of children's development in drawing as a dynamic event rather than as a series of artifacts shows a multiplicity of possible bifurcations, opening up like so many branching paths. For any individual, development is as unique as a fingerprint. This is true of any major aspect of development. For example, although we expect an infant to be walking at around age 1 year, the way in which this is achieved is as unique to that infant as her or his fingerprint (Thelen et al., 2000; Thelen & Smith, 1998).

CHILDREN AND ELECTRONIC MEDIA

Children's encounter with a new electronic medium offers a chance to notice and describe examples of these developmental journeys. Principles of development seem to operate at the intersections where bioprograms, representational medium (in this case, the video camera), interpersonal interaction, and chance meet. These principles of development are involved in the selection and organization of actions that serve expressive and representational thought. The insertion of the video camera into development gives us an opportunity to observe these principles as they operate.

The Introduction to Very Young Children of the Digital Video Camera

The digital video camera is introduced to the children as a device that they may investigate freely and use for its representational and expressive affordances (Gibson, 1979). Our earlier studies of children's development in representation suggest that development is an interaction between basic unfolding bioprograms and what is available within the environment in terms of tools, processes, experiences, and discourses.

However, there are limitations to the usefulness of such abstractions. Can we go beyond such global statements and discover and describe something more about the nature and principles of this development? Similarly, some people often remind us of the linguistic, cultural, social, and interpersonal dimension of development. However, it is insufficient—even misleading—to say that that adult support is “important” to or “part” of development. Adult companionship, discussion between adult and child, and that between child and child are inextricably woven into biological development. The present work gives us an opportunity to see how this weft is woven. By observing closely what happens at the “intersection” (Facer, Furlong, Furlong, & Sutherland, 2003) where developmental bioprograms meet this new electronic medium, we hope to describe development as it unfolds.

We see the children move through a sequence of different modes of interaction with the camera. This sequence is a weave of exploratory, representational, and expressive actions. There is order and meaning to it from the outset, from the first moment that the children, at age 2 years, are given the cameras. This already recalls our studies of children's development in drawing and symbolization overall. As in those earlier studies, what we immediately notice is that the children's development is not simply a case of a progression from a chaotic “mishandling” of tools (in this case, the video camera), through a usage evermore “corrected,” and eventually culminating in a “perfected” use. It is not the case that the children are merely trained in an apprenticeship toward a model of videography already in the mind of the teacher or, somehow, in the “culture.” Rather, the process seems self-initiated and self-driven, with the child moving through a series of interests in structures and relations that serve as attractors. These attractors guide and propel development. However how far development comes to fruition is to a great extent dependent on how adult companions conceptually construe children's activities and how they provide opportunities that enrich and extend children's spontaneously generated project.

We Gave Children the Video Cameras

In a nursery and kindergarten school in Singapore, Rebecca Chan and I were making video recordings of children drawing. The children were drawing terrorist airplanes crashing into

This was our first observation in which children themselves took part in video recording. Although we continued our study of drawing, this caused us to alter the course of the research. We held over the video cameras to the children.

METHODOLOGY

We commenced sessions in which we gave three video cameras and one to three tripods to a group of six to eight children. The children were between 2 and 4 years of age. We tracked the children's development with these video cameras over a period of 24 months. Thus, we traced the development of the 2-year-olds until they were 4 years old and the 4-year-olds until they were 6 years old.

Initially, our videography sessions were held every 3 to 4 weeks, but they intensified over the final 8 months to one videography session per week. Additionally, research assistant Rebecca Chan was the children's teacher, and she saw them nearly every working day for 24 months. Each videography session lasted 2 to 3 hr. Six of the children attended nearly all of sessions, whereas other children visited on occasions. The video cameras were marked clearly with indelible ink ("1," "2," and "3").

We gave the children three rules: "Do not drop the camera." "Always put the camera's strap around your neck." "Do not touch the camera's lens." Right from the very first session, they faithfully respected the first two rules—no camera was dropped or even mishandled. However, in their first encounters with the video camera, they almost invariably broke the last rule. They liked to touch the lens, thrust objects against it (but gently), and even kiss it. I discuss the developmental reasons for this later.

We recorded the children's behavior in longhand. Additionally, one of the adult investigators used a fourth video camera to make a general, overall recording of some of the sessions. We analyzed the many hours of video recordings made by both adults and children. What follows is a brief summary of what seem to be the main trends of development. This summary is by no means conclusive: Some of it is very sketchy, and much of it remains speculative. More research is required.

PLAYBACK

During or after each session of recording, the children had opportunities to view the playback of the material they shot. They watched this excitedly, on the camera's LCD, on a television screen, or on a laptop computer. Using computer editing software, I made a rough cut from the raw footage from the three cameras and showed it to the children the following week, before their next use of the video cameras.

The investigators discussed the movie while it was played to the children, either as a disc on a laptop computer or as a videotape on a television monitor. In this edited movie, the shots of each of the three cameras are interrelated and assembled to make one, shortened movie. Additionally, each different camera shot was titled Camera 1, Camera 2, or Camera 3. Thus, the children saw replays of the same events they had themselves video-recorded but from three different vantage points, or "station points" (Willats, 1997), and with each camera's station point labeled or marked, as it were. In some sequences, an event was seen once, with shots from the three cameras intercut

together to make one sequence. In other movie sequences, the children saw the same event three times but from three different station points, as captured by Cameras 1, 2, and 3, one after another. In either case, the investigators discussed with the children (who watched with great enjoyment and interest) how the movie was assembled. I do not have the space here for a full analysis of the conversation between adults and children and the levels of understanding that may be occurring. Understandings of representation, time, viewpoint, and personal history are all implicated, and we saw and heard (from how the children acted and the comments they made) that all the children were gripped by these dawning realizations.

This rough cut was not an attempt to tidy up, in any way, the children's work, nor was it a way of simply shortening the footage. The real reason was that the shooting of videotape alone was insufficient as a way of learning about the movie medium. This edited version was intended to foreground for the children certain aspects of their work. It helped bring out for them certain relationships in their videography, between their shooting and the visual, auditory, narrative, spatial, and emotional effects.

Of course, the fact that an adult edited their movies did raise important questions about the autonomy of the children in their work. In future work, we hope to give the children more authorship and control over moviemaking in the form of introducing them to computer editing software. (Whether this is an appropriate step to take remains to be seen.)

ADULT COMPANIONS

Although none of the adult speech to the children was scripted, all the adult investigators tended to give similar advice to the children, using words and body actions intended to describe the camera's line of sight to the scene. Although, as we noted, the camera is a blind machine, for simplicity's sake, in this article, I employ such metaphors as line of sight, point of view, and so on. When the adults talked to the children, they spoke of the camera "seeing" through its lens. I said to the children that the lens is like "the camera's eye." I offered this simile as a reason why one should not touch the lens: "It's like poking it in the eye."

VERY YOUNG CHILDREN USED VIDEO CAMERAS: DEVELOPMENTAL TRAJECTORIES

The children's investigation, discussion, understanding, and use of the video camera seemed to move through developmental trajectories that share certain general characteristics and that, at a deep level of description, are akin to development in other media, including drawing, music, dance, and sculpture. What happens is that the video camera teases out and encourages certain configurations of structure that we observed in children's development in nonelectronic and traditional media. Simultaneously, each child's development is unique.

This is not the paradox that it might sound. Development can be observed on different timescales, with some developmental shapes revealing themselves over relatively long stretches of time (Lemke, 2000). When we looked more closely, we saw other timescales, in which developmental patterns emerged in minutes and even seconds. We observed both kinds of timescale in the present study.

Also, these developmental pathways inextricably involved the adults who advised them. This involvement started immediately from the moment that the adults handed over the three video cameras to the children. When first given the camera, children tested out the device to try to find out what it was doing. Here is an sample observation: Adult investigator Hwei Yoke offered one of the digital video cameras to a 2-year-old named Tze Meng. Hwei Yoke was on her knees on the floor, keeping her head and line of sight aligned with the child's. The child had the camera's strap around his neck. Hwei Yoke maintained her own line of sight, which encompassed both the child's eye level and that of the camera. This allowed the phenomenon that they were discussing—the camera and what it was doing—to be within a field of view and action shared by both of them. Hwei Yoke helped him hold the camera up. The camera was a little heavy for the boy who, like some of the other 2-year-olds, needed two hands to support its weight.

Although smaller, more lightweight cameras now exist on the market, there are some advantages gained with the cameras used in the present study. The function buttons are bigger, clearer, and easier for fingertip control. This is not so important when the children, at age 2 years, first use the cameras, because they have little or no idea, initially, of the meaning of the signs and symbols printed on the buttons. However, like many children today, they may have some background experience of button-operated electronics (Facer et al., 2003). Later on, when they form ideas about the functions of the video camera and they want the camera to do something, then the control panel attains a semiotic significance. Consequently, the clarity and ease of use of the function buttons become important. There is not the space here to describe fully the children's learning of the symbol and sign systems peculiar to this silicon-chip landscape nor to do more than indicate the extent of the metaphoric universe that stretches away beyond it (but see Atkinson, 2003; Matthews, 2004a).

Of more immediate importance is the size and form of the cameras we used. The salient, streamlined length of our camera suggests a directionality to the child, which encourages the notion of pointing, aiming, and taking a sighting. In turn, this action encourages the development of line of sight and point of view. With the use of the video camera, taking a sighting also implicates the concepts of going-through and looking-through. These are core concepts in children's development in the use of the video camera. These are also concepts that guide early drawing. What happens is that different technologies tie these understandings together in different ways, creating different forms of expression and representation. I discuss the important implications of this later.

Hwei Yoke drew Tze Meng's attention to the LCD screen. He listened carefully to what she said. He suddenly realized that the relationship between the display on the LCD screen and the view before him. He was totally gripped by this realization. He was 100% intellectually engaged. It was for him (quite literally, figuratively, and optically) a revelation. He pointed out the view before him, making the connection between this and the view on the LCD screen. It was clear that he recognized that the images on the screen showed a small sample of the visual array before the camera.

Our studies show the dawning of this understanding even in babyhood. I observed Hanis (a Singaporean Malay) and Poppy (a White Londoner), both 8-month-olds, in their first encounters with a digital video camera. Their sudden realization of this relationship was startling. They looked repeatedly between the LCD screen and the view before the camera. They compared the two images: one in the real, three-dimensional world; the other on the flat screen. Microanalysis of the video recordings suggests that the babies used surprisingly precise visual and oculomotor skills to make this comparison (Matthews, 2005).

Meanwhile, back in the nursery and kindergarten, adult investigator Rachel was handing over a second camera to 3-year-old Seng Yiam, placing the strap around his neck. She supported and advised him, using explanations similar to those of Hwei Yoke. He also espied a relationship between the viewing camera and real scene in front of it. His next realizations followed on quickly. First of all, he realized that the camera need not stand still. He found that it may be moved and in two different ways, which he discovered in the following sequence. First, the camera may be moved around on its own axis or on an axis described by the movement of the camera operator's body. The camera may be swept through an horizontal axis by rotation of the camera operator's hips and upper skeletal frame. In movie parlance, this is a *panning shot*. In subsequent observations, the children discovered that the camera may be turned on its own axis, or *panned*, on a tripod, with the use of the pan head. This type of arcing movement is part of a generalized category of horizontal arc originating from the first generation of expressive strategies formed in actions of the infant's body in the first days of extrauterine life (Matthews, 1984, 1999, 2003a, 2003b, 2004a). Seng Yiam also showed the beginnings of another type of first-generation structure, and that was to move the camera through a vertical axis, that is, *tilting* the handheld camera upward by curving his spine backward.

However, his small size and limited strength curtailed the extent to which he could elevate the handheld camera. Here, a smaller, more lightweight camcorder might have influenced the type and range of camera movement. In other observations of Hanis (the Malay child mentioned above) at age 1 year, 7 months, we found that use of the tripod and panning lever greatly assisted and encouraged use of panning and tilting through horizontal and vertical axes, respectively (Matthews, 2004b).

However, despite strength limitations, Seng Yiam, like many of the children in this study, achieved, by tilting the camera upward, shots of the ceiling and ceiling fans and the brightly colored curtains, billowing at the high sunlit windows.

Both panning and tilting were combined with the second type of camera movement that Seng Yiam discovered. This type of movement was that in which the camera was moved forward through space, by walking with the camera held steady in both hands while maintaining visual contact with the LCD screen. As he moved forward, he made "in-flight" adjustments of the camera's movement. In moviemaking terminology this is a *tracking shot*. Again, this action derives from the earliest actions of the infant.

The tracking shot is based on self-directed walking, more precisely, the behavior of seeing something and then walking toward it. This, in turn, is a development of early reaching. In fact, I borrow the idea of in-flight correction of movement from Bower's (1982) studies of early reaching (cf. Eliot, 1999).

Seng Yiam had not been trained to make a tracking shot, nor had he seen anyone else use the camera in this way. Rachel simply set him free from her hands as one might set free a bird.

The Medium and the Message

Seng Yiam started to walk, carefully and slowly, maintaining his view of the moving image on the LCD screen while Rachel hovered behind him, ready to catch him should he have fell. He glanced and smiled briefly at me before returning his attention to the screen. I was nearby, assisting Woon Leng, 3 years old, recording with another video camera. Seng Yiam continued to make his tracking

shot, all the time realizing and carefully monitoring the relationship between the moving camera and the events in front of it. His visual attention alternated between the physical scene before the lens and its representation on the LCD screen. The children would have already started to learn core concepts of this visual praxis in their manipulation of toys and objects in representational play. In such play, the child would have manipulated the handheld object or toy while maintaining visual contact with it, sometimes shutting one eye to obtain a monocular image (Matthews, 1999, 2003). Through this play they learned about line of sight and the selection and framing of a view.

In this kind of play, the learning of techniques is driven by the child's expressive and representational needs. Similarly, when children pick up a video camera, the techniques they learn are the result of emotional and expressive urges. Within minutes of first picking up the camera, the fluency with which Seng Yiam performed actions on the device indicated that he was using it for a medium of expression. The camera became an extension of his brain and body. He was thinking with the camera. As in our studies of children's development in drawing and symbolization overall, we found that creative and aesthetic expressive aspects of the child's videography cannot be thought of as separate from the learning of technical skills. The two are entwined right from the outset.

Seng Yiam turned the camera to his friends, tracking from one person to the next. He again espied Woon Leng, who, with an identical camera, was recording him. I was bending on one knee, next to Woon Leng, assisting him. Suddenly, Seng Yiam realized a new possibility. He approached Woon Leng, pointing his camera toward Woon Leng's camera, which was simultaneously pointing at Seng Yiam's. With his camera, Seng Yiam carefully closed in on Woon Leng's camera, until the lens of Seng Yiam's camera actually touched the lens of Woon Leng's camera, which, with my support, was recording Seng Yiam. Seng Yiam ultimately captured an extreme close-up of the other's lens.

Televisual Jokes: Humor and Intellect

Simultaneously, Woon Leng, with me by his side, obtained (of course) a close-up shot of Seng Yiam's camera. I laughed at this event, as did Rebecca and some of the children. It was as if Seng Yiam, in collaboration with Woon Leng, had made a new type of joke: a videographic or televisual joke. Everyone, adults and children, found this funny and laughed. Yet it was surprisingly difficult to explain what made this action humorous. This fact was, in itself, of significance (Athey, 1977; Milligan, 1999).

We observed many instances of this looming-up play of camera to camera, and, at one level of analysis, the gentle collision of the two cameras, lens to lens, was in itself an event that the children found funny. This event is an example of trajectory and impact play, stage managed and enjoyed by children (Matthews, 1984, 1994, 2003a, 2004a). There are further levels of meaning, however, that have to do with the fact that, in this case, each colliding projectile visually represented, on a liquid crystal screen, its own trajectory and moment of impact. The two camera operators clearly perceived and anticipated the humor of this and fluidly, spontaneously collaborated in an unrehearsed ballet in which the impending moment of arrival was carefully calibrated.

The following week, a playback of the event was shown to the children on a television monitor, and all the children and the adults saw a movie sequence in which the shots of each colliding camera were intercut together. Thus, everyone got an opportunity to see what camera operators Woon

Leng and Seng Yiam saw, through the cameras, during the actual event. Again, everyone found this amusing.

At the time of the actual event, of course, Woon Leng and Seng Yiam alone saw what one or the other of the cameras “saw.” The other children, along with the adults, saw the event externally, as it were, from their own viewpoints. Even so, they seemed to empathetically participate in the joke.

It is suggested that this ability to empathize with the moving object and imaginatively experience the effect of its point of arrival is prefigured in interpersonal play between the baby and adult companion. In such play, the adult companion looms his or her face up close to the baby, sometimes accompanying his or her approach with musical and onomatopoeic vocalizations. Such play involves the line of sight of each player. Looming actions—especially those designed and deployed for the baby’s point of view, as well as those that, in a friendly way, intrude into the baby’s personal space—exploit the baby’s early emotions, in particular, the fine line between pleasure and fear (Osborne, 2003). This kind of play is prespeech and works because of our deep understanding of image and movement as indicative of intention, mood, and emotion (Trevathan, 2003). Looming play involving video cameras is surely built on such early ludic interactions between baby and adult companion, with the important difference being that, with the video camera, looming actions result in a sharply focused, video-recorded, moving image.

The notion of the absurd is also involved. The meaning and humor of this particular assembly of image and action have something to do with the absurdity of one camera’s viewing through its lens another camera, which simultaneously views through its lens the first camera. As noted, when the children saw playback of such sequences, they found it extremely funny. There may have been further layers of emergent mystery that began to fascinate the children. Once Cameras 1 and 2 confronted each other like this, there a certain type of reiterative cycle was set up and propagated, replete with its own philosophical mysteries about simultaneous time flows. It demonstrated the idea that your own personal time is different from my own personal time. It suggested a continuous, reiterative cycle in which “I am looking at you looking at me looking at you” and so on.

Of course, one has to be careful about overinterpretation, which may reveal more about adults’ rather than children’s interest. I admit to being influenced by contemporary films that play with ideas about memory, viewpoint, and the multiplicity of time, *Memento* being a notable example (Nolan, 2000). Several contemporary video artists are also fascinated by this representational cycle, for example, Nam June Paik (in Hanhardt, 2000), Douglas Gordon (1998), and Tricia Goh (2004).

However, because very young children also enjoy similar reiterative cycles in rhymes, songs, and stories, it is possible that they appreciate analogous visually reiterative circularities. The very young also appreciate the absurd, and many of the songs, rhymes, and “rounds” they enjoy are nonsensical—designed to exploit the child’s emergent interest in a distinction between real and unreal. Moreover, the very nature of the videographic experiment in which the children participate constantly confronts them with paradoxes about simultaneous, yet alternate, viewpoints and passages of time. The validity of this explanation is further borne out by other playful behaviors that we observed the children making, involving their pointing the video camera at a laptop screen on which the movies they made were being played. I describe these observations later.

I do not wish to overextend this interpretation, but I do suggest that such understandings are real potentialities, built into the children’s emergent video praxis. Perhaps the most important

point here is that humor and intellectual development are linked. It is not possible to joke about something unless you understand it. Learning and happiness are conjoined (Athey, 1977, 1990; Trevarthen, 2003).

Deep Patterns of Meaning

In our studies of children's drawing, we found that children move through successive generations of visuodynamic structure. In studies that I made with John Jessel (Matthews & Jessel, 1993a, 1993b), we found that variations of these generalized categories of movement were used by 3-year-old Londoners when they encountered a different electronic medium, a mouse-driven computer paintbox program. Peter Seow and I are finding this holds true with the more direct human-machine interface offered by the stylus-driven electronic painting tablet (Matthews & Seow, 2006). An important question to ask now is, how deep are these deep structures? Will variations of these deep patterns of meaning show up in children's use of this electronic, digital movie medium?

We found that this in fact did take place. What happens is that the characteristics of this medium cause the deep patterns of meaning to be assembled in different ways. Videographic representation is of a different nature from a traditional representational medium, say, a painting or drawing, or even a photograph or cinematographic film. This is not as obvious as it sounds. With the video camera, the relationships between the viewer, the representation, and reality have changed (Baudrillard, 1994; Berger, 1972; Dick, 1972; McLuhan, 1964). This difference involves ideas about the copy, the representation, and the thing itself.

It also involves time and memory. This means that to test the nature of the videographic representation, including the causal relations involved, the nature of its representation, and the expressive opportunities it affords, the children intellectually engaged with the device, the video camera, in a different way from that in which they intellectually engaged with other media. Again, this may sound like a truism, but think of what it means. As a consequence of initial emotional and intellectual engagement, deep strategies of intention and enquiry—incorporating handling, viewing, and vocalization in synchrony with movements of other body parts—are orchestrated differently from the way in which they are assembled with other, traditional representational media.

In our earlier studies, we discovered that successive levels of dynamic structure are generated by the child in relationship to surrounding media. Initially, these structures take the visible form of body actions, including large-scale motor actions of arms and legs to smaller actions of the fingers, facial muscles, eyes, mouth, plus the action of vocalization. These actions, however, must not be thought to be only "physical," because, from their emergence in early infancy, they have psychological, representational, and expressive characteristics embedded deep within them. These action assemblies are analogues or metaphors, deep patterns of meaning having to do with connectivity, touching, right-angular attachment, trajectory, point of arrival, going-into, going-through, and collinearity (or being in line with).

First-generation structures are transformed by the videographic medium, and some actions are changed almost, but not quite, beyond recognition. First-generation actions are used in two sorts of ways: One way is that of when they are used in front of the lens, and another way is that of when they are used behind the lens or behind the camera, when the camera operator uses LCD or viewfinder. First-generation actions of waving, looming, and touching are used before the lens to as-

certain that it is indeed viewing, or “seeing” (as the children and adults put it), and simultaneously what it is seeing. This, then, is the category of action that is made before, or in front of, the lens. The actions become actors (so to speak—if the reader will allow another pun).

Actions in the second category of the actions performed behind the camera are transformed in another way. For example, horizontal arc becomes panning, whereas another first-generation structure, vertical arc, a downward stabbing, is coaxed along another developmental passage, to become movement up and down through a vertical axis. They become new hybrids of first-generation structure. In turn, this means that the relationship between first-generation structure and following structures, as well as their subsequent sequencing and coordination, will be different from the sequence of structural organization observed in the child’s use of other media and from action assemblies involved in the use of pencil-and-paper technologies.

For example, the use of the tripod’s pan head with the camera nudges development toward an earlier configuration of moment of turn and angular variation. This causes variations in second-generation structure, continuous rotation (going around and around), an example of which I describe shortly. The emergent concepts of going-into, going-through, and looking-through are particularly favored by the video camera, which also encourages their coordination with the emergent concept collinearity (or being in line with). Basically, then, we are writing of a dialectical relationship between the thinking, feeling child; the medium; and the adult companion, in which the emphasis is changed according to exposure to particular media (Wolf, 1989).

Looming and Zooming

In early sessions we observed the children making all sorts of swoopings-in on the lens. Some of these looming trajectories ended in physical contact: A palm was clamped over the lens; a toy pushed gently up to it. These were not acts of vandalism but together constituted a series of sensuous strategies the children deployed for testing the camera. These strategies were combinations of expressive and communicative actions originating in infancy. This particular action assembly (Thelen & Smith, 1998) comprised our first way of gaining knowledge of the world, the *sucking scheme*, plus the dynamic structure, *trajectory and moment of impact*. The latter dynamic structure, trajectory and moment of impact, underlay the suicide-plane drawings mentioned earlier.

In their first encounter with the video camera, the children learned quite quickly that to obtain a visual image, physical contact with the lens was not necessary; however, faced with this new medium, they used a developmental variation of this powerful fallback strategy to confirm their understanding. The scheme was retuned as soon as it was performed on this new medium (Gibson, 1979; Piaget, 1951). In the earlier example, the lenses of two cameras met on a careful collision course in which one discerned a sensitivity to the delicacy of the device, especially its glass lens.

Children also loomed their faces into the camera’s field of view, sometimes licking or kissing the lens. The consequences of a trajectory ending in a lick or kiss were clearly displayed for the children when they viewed footage that had a blob of spittle in the center of the screen. After about 18 months, we observed a decrease in the child’s touching of the lens. The child increasingly appreciated that the critical factor determining whether or not one obtained an optical sample was not the proximity of lens to subject but the lens’s visual angle and the whereabouts, within this, of the subject.

This is a projective understanding, and it follows on from a predominantly topological understanding. The potentiality of projective understanding was present from the outset, but the insertion of the video camera into development enticed out this embryonic understanding and encouraged its growth. Thus, we saw how varying the initial conditions would vary the sequence and configuration of action assemblies.

As I will show, looming play would provide the background for the later use of the zoom lens. Both emergent concepts of going-through and looking-through grow out of the concept that developmentally precedes them, that of going-into.

It may be that the children want to get into and go through the camera but in an imaginative sense. It may be that, because of the nature of the video camera, the emergent concept of going-through is propelled into a imaginative dimension. Because it is not physically possible to go through or push things through the camera, this medium persuaded the children toward an imaginative passage through the camera.

Human and Machine Line of Sight

These experiments are intertwined with and related to another set of experiments that involved the children that had to do with the relationship of the image on the LCD screen and the image displayed through the viewfinder and the relationship of each and both of these images to the scene before the camera. Very noticeable were the children's persistent investigations of the LCD screen and viewfinder and their comparison of these two devices for showing images.

The LCD screen was in color whereas the viewfinder was in black-and-white. On this particular model of camera, one has the choice of using either the LCD screen or the black-and-white viewfinder. These two ways of viewing do not, on this model, function simultaneously. The screen functions automatically when opened. The viewfinder switches on when the LCD screen is closed down. In the first sessions, some children attempted to look through the viewfinder while the LCD screen was open and so failed to receive an image through the viewfinder. Some children persisted in this behavior, probably because their experience with physical tubes lead them to the expectation of a straight line of sight through this new type of tube toward the view beyond. This perseverance was especially noticeable when the child had previously succeeded in obtaining a view through the viewfinder.

The two ways in which the optical array was presented, viewfinder and LCD, though different in color, were identical in terms of their projective geometry. Perhaps the children repeatedly switched between views to double-check that this was so. Additionally, perhaps the replication contradicted the child's experience that even slight changes in position resulted in slight differences in image. These very young children had already made the discovery of the relationship between optical sample and position of viewer. When new phenomena contradict this or, at the very least, complicate the issue (like the combination of similarities and differences offered by viewfinder image and adjacent LCD image), the children set out through experimentation to ascertain the true situation.

Aside from the difference in color, there are other important differences between viewfinder and LCD that have to do with the ways in which the optical sample is relayed to the viewer. The LCD screen presents the image to the viewer, who becomes an audience for this presentation. The viewfinder, on the other hand, requires a special kind of peering and seeking: the taking of a sight-

ing. Such differences might set up differences in viewing practice and moviemaking (differences that incidentally give us a clue to an underlying and important expressive difference between cinematographic film and videographic movie).

Arguably, the viewfinder system more closely mimics the human visual system than does the LCD system because it creates the illusion of a virtual tube, through which one might peer, in a straight line, toward the scene at the end of a tunnel. In fact, the axis of the viewfinder, although close to and aligned with the lens's focal axis, is different from this axis. The difference is slight, and, in practice, adults do not seem to notice any disparity, or at least they override it easily. Whether the children, when they first looked through the viewfinder, were aware of a disparity was not so clear. They quickly behaved as if it were a virtual tube, but we do not know what they saw nor what they understood by what they saw, when they took their first peek through the viewfinder. There are, of course, fundamental differences between human vision and machine vision. Light travels to both human and machine lens in sheaves of straight lines, but it is at the lens that all similarities end. In both viewfinder and LCD systems of the video camera, light information is translated into an electrical signal and is relayed to the human eye, via LCD or viewfinder, on a route that is no longer straight.

However, by the same token and in a restricted sense, the visual system of the digital video camera (rather than the film and cinematographic camera, in which optical information is directly transmitted to the surface of the film via the lens) recalls human vision, in which information in light is transduced into an electrochemical signal and relayed through a number of subcortical and cortical structures before it is perceived as an image. Both human and machine vision is "screened" in different ways (Haddon, 2004). Even the idea that we "look through" our eyes, as if out of twin openings of a cave, is a metaphor.

As noted, the LCD's first position, when opened out from the camera's body, is aligned with the lens's focal axis so as to easily map onto the human operator's visual relationship to the scene. The viewfinder, like the telescope, directly mimics human line of sight. However, although both systems, LCD and viewfinder, are designed to emulate human lines of sight to scenes, they need not do so—and this is the big difference between videography and cinematography. Televisual images may be displayed anywhere in physical space, connected to only the original optical array by an electrical signal (Baudrillard, 1994; Finch, 2003; Lincoln, 2004; Mirtzoeff, 2002). Televisions do just this—*tele-vision* means "seeing from afar." Television directors may sit in rooms thousands of miles away from the cameras, making decisions about which line of sight or point of view to select.

Similarly, with the video cameras used by the children, only one of the many possible positions of the LCD screen resembles human, direct line-of-sight to the scene. This is the first position that the LCD device clicks into when it is opened out from the camera's body. Here, at right angles to the main axis of the camera's body, it situates the screened image in line with the axis of the camera's lens system to the scene. This position is the one that most closely corresponds to the axes of viewfinder and the human line of sight. However, the LCD screen may be swiveled to adopt three other main positions, plus a continuous series of positions through moments of turn from one of these positions to the next, all of which contradict human line of sight. Even the first position of the LCD, though close to the axis of the viewfinder, is adjacent to it.

Typically, in a complex set of experiments, the children tried placing objects both behind the LCD screen and in front of it. Five-year-old Zhou Quan, for example, having already successfully and enthusiastically tracked and panned the camera, now investigated how the LCD screen works.

The camera was on the floor, with the LCD screen in its first position, that is, that which was most closely aligned with the camera's line of sight and in the orientation that most closely corresponded to human line of sight to the scene. The screen displays the present, ongoing events happening before the camera. Despite the gentle advice offered by Annabel, his adult companion, Zhou Quan persistently placed objects in front of the screen, starting by physically abutting the object at right angles against it. Annabel accompanied her speech with repeated pointing movements of her index finger in toward the lens. Although she struggled to find suitable terms, she was essentially trying to explain that the visual information entered the lens and came out onto the LCD screen and that, if Zhou Quan wanted an image to appear on the screen, then he had to place the object before the lens.

Zhou Quan's response was to jump in front of the lens and reverse the position of the LCD so that he could now see both screen and lens from his new position in front of the camera, where he at once recommenced placing objects against the screen, as if to display them there.

The methods he used are noteworthy, for they are examples of the deep patterns of action that I argue are behind all representational and expressive acts. Zhou Quan abutted the object (a toy lorry) physically against the LCD and aligned it at right angles to it, that is, with the front of the lorry touching the screen. When this inevitably failed to result in an image, he waved the toy just before the lens.

His choice of strategies is significant, suggesting topological and dynamic thinking equivalent to that shown in children's representation in other media, for example, in pencil-and-paper technologies. In drawing, to obtain maximum differentiation between two 2-dimensional shapes, children often join and align them at right angles to each other. Another way of sorting out, in drawing, the causal relations between actions and visual effects is a fanning action of a mark-making tool across a surface (Matthews, 1984, 1994, 2003, 2004).

Similar investigations are made by other children. For example, another child (a 2-year-old) also investigated the viewing system of the video camera while it rested on the floor, but this time it was the viewfinder that captured the child's attention. He placed a wooden block in front of the viewfinder's eyepiece. He then aligned his own eyesight with the block and then the eyepiece before it, in a direct line. Finding that this did not result in a displayed image, he quickly relocated the block against the lens of the camera, fanning the block gently up and down while viewing it through the viewfinder.

In such cases, an emergent concept of alignment seems to be involved, with the children trying out different assemblies of strategies to ascertain the sequence that results in a visual representation. Of equal importance to them may have been the systematic discounting and discontinuing of ensembles that fail to result in visual representation.

There are a variety of ways in which strategies are assembled. Some children, having realized that to obtain a view of an object requires its placement before the lens, then surmise—incorrectly, as it turns out—that for the object to be displayed on the LCD screen requires its similar positioning before the reverse side of the LCD screen. Remember that adult explanations to children often involve pantomimetic demonstrations that utilize somatic metaphors—for example, for the camera to see the object, the object must be placed in front of the lens, the camera's eye. Extending this metaphor, I explained to the children that objects cannot be seen if they are placed behind one's head but have to be presented before one's face (in which place, of course, the eyes are situated and can see the object). Some children deployed strategies in accordance with these somatic metaphors, hypothesizing that to obtain a view of the object, it should be presented in front of what they

might construe as the “face” of the LCD device (in reality the reverse, or backside, of the screen). When they placed objects to the backside of the screen, they were overgeneralizing their hypothesis, for placing the object before the reverse of the LCD device, which (I am arguing) they are now considering as its “face,” of course fails to result in a view of the object.

However, such experiments show the children’s logical thinking and the experiments they run to ascertain the truth. After a series of trials, most 3-year-olds came to realize that an image was obtained, in viewfinder or in liquid crystal, by placing the object before the lens. We saw the children learn to coordinate the action of holding the object against the lens while viewing its image on the LCD screen—a combination of actions unique to this videographic medium. Adult advice, couched in terms of metaphors about the camera’s “eye,” helped to consolidate this knowledge. Even so, from the first sessions, most of the children preferred to use the black-and-white viewfinder rather than the colored LCD screen. Interestingly, their preference contradicted my expectation that the LCD, being in color, would be more attractive to the children than the monochrome viewfinder. It is because of this expectation that the camera was often presented to the children with the LCD screen opened out. I surmised (mistakenly, as it turned out) that the LCD screen would be preferred because it was more immediate and did not require the special skills involved in taking a sighting through the viewfinder. However, as we have seen, there are special skills required for using both viewfinder and LCD. The skills are different in each case, signaling subtle but important differences in visual praxis, but are ultimately unified by the child under an overarching understanding about electronic and human lines of sight.

As the children came to realize the relationship between the LCD image and the scene, they quickly appreciated that the LCD always showed the view obtained through the camera’s lens, no matter what the orientation of the LCD. Children came to this realization at different speeds and in different ways. In an observation of Hanis, age 1 year, 7 months, after a series of trials, this infant seemed quite happy to view the scene as displayed in liquid crystal, despite the fact that the LCD’s position was reversed, obliging her to repeatedly turn her head to see the real scene. Subtle differences in the ways in which the video camera was introduced to children—accompanied by differences in the language used by adult helpers, plus small but sometimes developmentally significant differences in the child’s age—may initiate slightly different developmental trajectories. More research is needed here. In general, it seems that even the very young are sensitive to view-specific information and are surprised when their expectations are disrupted even slightly.

The video camera, once inserted into representational development, encourages one particular strand of visual praxis: that of taking lines of sight and capturing “views.” This requires us to further modify ideas that the very young are somehow locked into a state of egocentricity. In the present study, it appears that, although in certain overall respects Piaget’s idea remains germane, there are other ways in which the video camera encourages understandings of line of sight, including those of other people, which are not accounted for in Piaget’s theory of egocentricity. While Piaget did concede that, in cooperative tasks, very young children might be obliged to be a little more allocentric, the kind and quality of the conversations that we observed (and of which we, the adult researchers, are sometimes a part) seemed in stark contrast to an underlying egocentricity that Piaget seemed to posit (Piaget, 1959/2002). The child’s investigation and use of the video camera would seem to provide for her or him an arena for decentering. However, the interlocking issues of egocentricity, of views and points of view, are complex and subtle and require more research.

Before I leave, for the moment, these ideas about views, I should note that the child's investigation of that ordinary, yet extraordinary, material, glass, is also implicated (Macfarlane & Martin, 2002). Glass, more than any other technological innovation, makes a special approach to representation realizable. Further research is also needed about the child's discovery of glass.

Going-Through, Looking-Through, and Blowing-Through

When children start investigating particular forms and relations, they carry their emergent understandings across media domains. One example is that of when the children alternate between looking-through the viewfinder of the video camera and blowing-through flutes.

As a joke, Yo Kiat put his hand against the lens of Charmaine's camera to prevent her seeing (interrupting her line of sight). Then he clamped his hand over the end of Charmaine's flute, to stop her playing (stop her breath coming through). We observed the action of the palm clamp frequently.

Occasionally, we were lucky to see examples of deep patterns of meaning liberated in representational play. A beautiful example was that of when Faith "played" with the dynamic structure of going-through. While being video-recorded by Favian and Yo Kiat, Faith sat at a table, drawing. She paused in her drawing for a moment to lift a small wooden column up to her mouth. She was pretending that it was a metal drink can. She mimed pulling a metal ring tab and even synchronized a *pschhh* vocalization to represent the sudden escape of gas. She then lifted the wooden column to her lips, arched her head backward for a moment to enact taking a quick drink from the can. She then replaced the wooden column, upright on the table, and went back to work on her drawing.

This observation beautifully illustrates the interpenetration of play and nonplay. During a real task, this child took a representational drink break. The ludic and nonludic fluidly alternate. The opportunity to play is vital for full understanding to take place (Athey, 1990; Bruce, 1987, 1991; Piaget, 1951; Vygotsky, 1966) because it allows the child to "uncouple" objects (and therefore ideas) from here-and-now reality and to explore them in a world of imagination (Garvey, 1977). In so doing, she discovered permutations and possibilities of structure.

Faith's representational play with the wooden column is a stunning example for another reason, too. This is the fact that, unbeknownst to the adult investigators, it was recorded by two of her classmates of their own volition. We discovered this sequence later, when I reviewed the raw footage on a computer.

A fascinating possibility presents itself here. Can children document their own development? What would this mean, exactly? This prospect would revolutionize how we describe development and how we conceive education because the children might be able to show us their own points of view, literally and metaphorically. Perhaps they could show us their own shifting interests and changing focuses of attention. The scope for research here is exciting.

Going Around

Another important dynamic structure, continuous rotation (going around and around), also manifests itself in videography and is transformed by the video camera.

Again, this shows itself in two basic ways, which, again, for convenience, I refer to as *in front of the lens* and *behind the lens*. Both types are noted in a single observation of two boys, Leonard and Zhou Quan. An example of the former is that of when Leonard dances around the camera, and the second type is that of Zhou Quan's rotational tracking shot of Leonard performing this action.

Continuous rotation is an important structure in children's spontaneous drawing and dance. As with other expressive action assemblies, the video camera transforms it and rearranges its relationship with the other members of dynamic structure.

Leonard's orbit around the camera recalls the kinds of rotation in drawing and painting in which children rotate a pencil or brush around an axis (perhaps a paintpot in the center of the paper) or perform continuous rotation in dance around a central object. As with other early generations of expressive structures noted here, when rotational movements are translated by the video camera, an important difference takes place. The hub of the rotation is now a machine that records Leonard's orbit around it.

The developmental sequence through which Zhou Quan's camerawork has moved to his achievement of a 360-degree continuous pan recalls drawing development. In drawing, the horizontal arc is "opened up," as it were, to become a continuous rotation. As described earlier, the video camera translated the horizontal arc into a panning shot. Now, in the present observation, it is fulfilled as a continuous rotation about an axis, or a 360-degree pan.

Later on, we observed Zhou Quan tracking elliptically by turning clockwise on the spot while aiming his handheld camera outward. Favian, next to him, also holding a camera, observed this with interest and instantly imitated this twirling but in an anticlockwise direction. Does Favian's ability to copy the other boy imply some emergent allocentricity on Favian's part in that he knew, in advance, that he would obtain a similar optical effect? Or does it simply mean that he imitated Zhou Quan spinning around with a camera in his hands?

Revolutions

This physical revolution is a small part of a larger intellectual revolution. Understandings of moment of turn and line of sight are repeatedly revolutionized and overlapped with continuous rotation. An example of this is that of when Yo Kiat signaled, with hand in front of lens, the position toward which one of his friends should move to be within the lens's visual angle. On the playback of his movie footage, we saw Yo Kiat's open straightened palm in front of lens, describing an arc that moves left-right, left-right, "hinged" (as it were) from the wrist. This implies the development of projective understandings. The development of techniques is inseparable from the development of ideas.

Zoom

While all this is going on, the children discovered the use of the zoom/wide-angle function and gradually mastered it. Once they discovered this facility, some children repeatedly practiced zooming in and out. Certain children took particular delight in this, laughing at the effect. Zooming in and out has a prehistory in the looming play the children engage in with traditional toys and objects. As was noted, in turn, such play may be traced back to the looming play between adult com-

panion and baby. This is the kind of play in which the emergent concept of approach and retreat is exploited by adult companion when she or he looms into the baby's personal space. The adult companion becomes a "friendly frightener," testing the baby's thresholds of happiness and fear.

The telephoto/wide-angle device transforms these actions into a virtual moving toward and a virtual backing away. In fact, the investigators employed this kind of analogy when explaining the zoom function to the child. "It's like you are moving in more closely—yet you don't have to move the camera."

This in-and-out virtual motion is accompanied by adult advice on how to press the wide-angle/telephoto button, first one way and then the other. As with other videographic functions, we noted that the child's learning of the technique of zooming in and out cannot be analyzed in terms of skills learning alone, for, while learning these techniques, the child simultaneously exploits them for their expressive effects.

Through the Looking Glass

A wonderful example of this is the creative use of the zoom by Favian, who repeatedly zoomed into and out of the movie image on the laptop computer screen. It was Favian's idea to set up the camera on a tripod and point the camera at the laptop screen. Playing on the screen was last week's movie of him and his friends using the video cameras. Favian then trained the video camera at this screen on which the movie was playing.

Favian zoomed slowly, slowly, into the laptop screen on which could be seen imagery of him and his friends, using the same video cameras, in the same classroom, but video-recorded one week earlier. What is so remarkable about this sequence was Favian's consciousness of what he was doing.

Going Into the Computer

"I go into the computer," he said as he slowly zoomed into the screen while the screen simultaneously showed similar zooming in and out.

His camerawork is conscious and expressive, involving humor and ideas about the real and unreal, as he enjoyed the thrill of the virtual rush into image within image on the laptop screen. The sequence recalls contemporary movies in which tracking, while simultaneously zooming in or out, creates mysterious transitional spaces in which different flows of time and space slide into each other, actors momentarily immobilized while the background scene is in motion.

These are effects that play on the real and the unreal. We appeared to pass through window after window into an unceasing succession of realities. He chuckled with pleasure at these effects and talked to his friend about them. He knew exactly what he was doing. Like Alice through the looking glass, he played at passing through a transparent screen into an imaginary world.

I write that the deep patterns of meaning are almost changed beyond recognition—almost but not quite. They are linked by their common origin, as actions generated from within the child that embody expressive and communicative intentions. However radically they might be transformed by developmental interaction with novel devices, these deep action patterns still retain distinctive traces of their expressive and communicative histories. The video camera itself is an embodiment

of these patterns of meaning, and the child's entry into moviemaking is an entry into an expanded world of semiotic systems.

Very young children, when they are forming representational thought, use all manner of media, ranging from sophisticated electronics, to pencil and paper and found objects. As Athey (1990) has pointed out, the children are not merely "flitting" from one activity to another but "fitting" (p. 107) actions together to form patterns of meaning. To this end, in the present study, the children clearly found traditional media, including musical instruments, wooden blocks, and even a cardboard box, of equal interest to them as the video camera.

Cameras and Cardboard Boxes

Some of the children liked to erect the camera on its tripod inside a large cardboard box that Rebecca Chan supplied them and to video-record from inside. They found this cardboard box just as interesting as the video camera. This was of particular importance to us. In terms of expressive and representational affordances, the cardboard box (trash) is, to the children, of equal value as the video camera (expensive commodity).

The cardboard box was used for its inside-outside relationships. One of the attractions for the children of using the camera on its tripod within the box was that the box presented a clearly demarcated boundary, separating inside from outside.

Drawing, Painting, and Writing

Drawing, painting, and writing materials are especially favored by the children. They would typically put aside the video camera to draw and write with the graphic materials supplied them, which included pencil, crayon, and paper and small whiteboards and markers.

Drawing allows young children to represent topological and dynamic aspects of reality with reference to the flat surface. They represent the following relationships: trajectory and point of arrival, continuity and discontinuity, points in space, inside and outside, closure, boundary, hollowness, touchingness, connectivity and collinearity (or being in line with).

As we have seen, these concepts played a part in the children's use of the video camera, but their translation into the movie medium reconfigured their relationship with each other and afforded them new expressive dimensions. One general transformation was from the topological to the projective. To a certain extent, projective relationships were represented in drawing, but videographic and other lens media accentuated and encouraged the transformation of topological to projective thinking. Touchingness and connectivity were involved in early strategies that the child deployed to test the causal relations involved in the video camera's visual system. Recall children's early touching of the lens and the abutment of objects against the LCD and viewfinder. Gradually, the child came to understand that visual capture was not dependent on the subject's physical connection with the lens; rather, what was required was that the subject be situated within the lens's visual angle. This was a move from a predominantly topological understanding to a projective one.

Similarly, the concepts of trajectory, continuity, discontinuity, and points in space are transformed by videography in two main ways. One occurs behind the lens when self-locomotion is translated into camera movement that is in turn translated into a video recording of the optical flow through an sequence of changing vistas (Gibson, 1979). The other is in front of the lens when the children make actions for the camera's line of sight.

It is easy to see that continuous linear motion (in the form of walking and running, for example) and discontinuous displacements (in the form of hopping and jumping) may be represented by actions performed in front of the camera. A more subtle argument is that experience of time in terms of both continuous flow and points in space (represented in other media, including dance, music, and drawing) form a background for the child's understanding of both the continuity and the discontinuity of time involved in the nature of the movie. This must remain speculative, though such understandings may be dawning when the children make intertwined investigation of both "still" and "movie" functions of the camera and when they watch slow-motion sequences and handle "flicker books" made for them.

Children's understandings of camera movement also merged into concepts of projection, taking a sighting, and line of sight. These were coordinated and assembled with those of inside and outside, going-through, looking-through, and hollowness, in a different way from the way in which they are assembled with pencil-and-paper technologies. Consider, for example, how these concepts apply to the use of LCD and viewfinder, when, for example, the topological relation of an image being "inside" the LCD screen is simultaneously linked with the image being "outside" and "over there." I consider this particular aspect fully when I consider deictic terms in conversation.

In drawing, as children become familiar with the nature of graphic two-dimensional media, they reconceptualize the drawing surface as a frozen moment in time, a glimpse that goes on forever. However, children represent the flow of time in drawings, too, first in dynamic tracings of the marking instrument in action representation and later on in serialized images (Matthews, 1984, 1994, 2003, 2004). Perhaps the introduction of the video camera helps children with their project of representing the structure of events. In this light, the medium of videography assumes an appropriateness for the very young child, because it fits into her or his basic representational agenda of finding ways to describe the shape, location, and movement of objects and persons.

A word of caution is needed here, however. Electronic and lens media should not be prematurely imposed on children's development to the exclusion of other media. For the child to fully develop understanding of the electronic representation, she or he requires thorough immersion in topological and dynamic modes of thinking so that she or he is able to make links between the physical and the virtual.

The Flow of Time and the Frozen Moment

In the present study, the children made a link between the "still" and "moving" pictures when they discovered, by themselves, the relation between the video camera's stills and movie functions. We speculated that the children's taking of still pictures helped them make an intellectual transition to the understanding of "moving" or "progressive pictures" (Gibson, 1979, p. 293). The reason may be that, as Osborne (2003) suggested, this allows the child to escape, for a moment, from the perpetually unfolding present.

Electronic Paint

Children seemed to test out the reality of the camera in sensuous ways. This sensuousness clearly manifested itself in the way that they liked to physically thrust their faces into the camera's lens or even kiss it or carefully collide one camera lens into another's lens. This sensuous quality showed itself in subtle ways too, in the way in which they handled and used the camera generally. In recent

studies it has been noted that the things at which children point the camera rarely form the subject matters chosen by adult photographers. Studies such as those of DeMarie (2001) and Sharples, Davidson, Thomas, and Rudman (2003) are useful because they show that children, left to their own devices, point the camera at subjects that might not attract adults.

We also found that children point the camera toward favorite objects. They also like to place their toys in front of the camera. However, I believe that there is another aspect of their videography that is less an object orientation and more a delight in a new aesthetic (Osborne, 2003; Presser, 2004). The children seemed to sensuously play the camera over textures, colors, not so much for the objects in themselves, but for an enjoyment in luminosities and colors. This idea is supported by children's obvious enchantment with prolonged out-of-focus shots, in which color is liberated from its usual enclosure within clearly delineated shapes. It is as if the children are using electronic paint (Matthews & Jessel, 1993a, 1993b; Matthews & Seow, 2006).

PRINCIPLES OF DEVELOPMENT AND THE ROLE OF THE ADULT COMPANION

I have noted several times in the present article that it is at the interface among the possibilities of the medium, the thinking child, and the contributing adult that development occurs. I do not have the space here to fully elaborate on the processes operant at this interface, but I do want to emphasize a few general principles, especially about the role of the adult companion. One key point is that development exhibits characteristics that are general to most children yet are simultaneously unique to each individual. Development appears universal and stagelike from a distance (to use Thelen and Smith's apt metaphor, 1998), yet, when looked at more closely, it reveals bewilderingly intricate context-specific detail, making each individual developmental trajectory unique. How then to reconcile stagelike narratives with the unwritten, unfolding development as lived by the living, in which unplanned, random perturbations incorporate themselves into developmental pathways (Atkinson, 2003) and in which adult interaction and provision is often the result of spur-of-the-moment choices rather than decisions based on developmental theory? In real development, in real time, things done cannot always be undone and things said cannot be unsaid. Some on-the-spot choices may allow for endless amendment and qualification but never erasure. Real-life events (unlike the stories that we tell about them) can never be deleted as if they never existed.

This real experience of events in time contrasts with the kind of abstract developmental time in which tales told about growth and learning become monuments against which moment-to-moment, real-life development is futilely measured. Once we insert a new representational tool (in this case, the video camera) into the developmental trajectory, we have a chance of seeing afresh the principles that unfold development.

The challenge is to describe what happens at this interface so as to reveal key principles of development but in such a way that helps us make use of and enjoy what Lin (2003) has called its "relentlessly relational" nature rather than reduce development to blueprints doomed to disappoint us with their inadequacy. These new descriptions will, ideally, illuminate the principles useful to adult companions in their support of children's representational and expressive growth.

To a certain extent, insertion of electronic media reminds us of principles of development and representation sometimes obscured by our long familiarity with analogue representation, written text, the technologies and tools of handwriting, painting, and drawing. These new technologies of

image making redefine representation, and persistent issues about the relation between the representation and the real are seen afresh. It might be the case that the nature of what we might term *e-presentation* allows us, as adults, to participate in and discuss, with the children, the process of development as it unfolds for all of us, children and adults together. As I noted, development does not allow replays or erasure, but, significantly, videography does allow exactly those things. Also, by giving us opportunities to see multiplicities of viewpoint (at least in terms of this electronic and lens medium) we are offered demonstrations of that which is so difficult for each of us, in life, to comprehend: that there is something outside our own selves, that there are other points of view. In helping children understand videography, one might simultaneously elucidate processes of development in which we are all involved.

However, electronic media are no magic pill for pedagogy, and I want to avoid science fiction rhetoric about a supposed educational revolution that information technology offers. The real issue is our attitude toward teaching and learning. All the same ambiguities of meaning, about the relation between the representation and the represented, persist with *e-presentation*. They have been but recast and reamplified. Additionally, despite the rhetoric about the digital generation, some of which would have us believe that these children have totally different brains, electronic media provide no shortcuts for development. The present study suggests that children move through an evermore controlled investigation and increasingly sophisticated play with this electronic and lens medium, akin in important respects with their development in pencil-and-paper technologies. As shown in my studies of children's development in other representational media, there is, in children's development of videography, no single, absolute endpoint of mastery. As with drawing, different types of mastery are gained from the outset. What happens is that these phases of mastery are momentary; further discoveries, interventions, and accidents oblige the child to update and revise her or his understanding and use of the medium. This infinitely complex dialectical relationship also includes the adult companion.

Guided by the child's emerging and changing interests in the medium, the present investigators supported the children's exploration and suggested ways that might better achieve their aims. The adults tried to be sensitive to those moments in the child's development when they thought that exposure to certain ideas about moviemaking and about the camera's functions was timely. What made for "timeliness" was the identification by the adult companion of the kind and quality of the child's thinking at particular moments in development. A simple but telling example in the present study was the onset of the child's readiness to comprehend and use the record/standby (REC/STBY) button on the video camera. We found that only after several hours of the children's spontaneous investigation of the camera was there anything gained by attempting to explain this function to the children—as basic and necessary as this might seem to an adult "curriculum" designer. The child became aware of the function of this little red button only as it became significant to her or him—that is to say, when a conception of recording or not recording starts to dawn and differentiating these states becomes important to her or him. It is at this moment that she or he starts to learn to read REC in red, STBY in green, and that these are abbreviations for—they are short for—"record" and "standby." We found in the present study that from here, other signs and symbols peculiar to this silicon-chip universe may be introduced and explained in terms of the metaphors from which they derive, including the "progress bar," which graphically displays the "filling" and "emptying" of the battery with "energy," and the buttons that allow the "playing" and even the "winding" and "rewinding" of time.

It is not the case that the children's development is dependent on, or even follows, adult instruction; in fact, the paradigm of an "instructor" is to be avoided. In the present study, the adult based the insertion of her or his own ideas into this epigenetic landscape according to how she or he conceptually construed the child's developmental movement. Rather than think in terms of what constitutes "good" or "bad" adult contribution (although, to be sure, there do exist forms of "teaching" totally abusive to development) it is perhaps more helpful to realize that each instance of adult provision and interaction will produce a cascade of consequences. The "good enough" adult companion (Winnicott, 1971) will allow the child to initiate searches along a self-initiated developmental route. Though adult advice may be less than accurate, as long as there is sufficient flexibility and as long as the companion adult is continually revising and reviewing her or his inputs in the light of what she or he understands to be the child's general pathway, development will still proceed.

In the vignettes offered, the adults, when they advised the children, were themselves trying to understand the machine and what it was doing. Despite their efforts, the language they used to explain what was happening was often far from clear. As with other forms of representation, including pictures of many types, it is important to use language that differentiates between the representation and the real. The nature of the televisual representation causes stress on the understanding of deictic expressions—that is, on the task of uncovering the intended meaning of such terms as the deictic adverbs *here*, *now*, and *then*, as well the intended meaning of the pronouns *I*, *you*, *him*, *her*, and *them* (Yule, 1991)—notable especially when multiple replications of a portrait are involved. Even the use of prepositions is not straightforward. Consider the complexities involved when the words *in* and *inside* are used when talking about *you*, *him*, *her*, or *them* (as images) *in* or *inside* the LCD or viewfinder, for example, in questions and statements like the following: "Can you see Uncle John *in there*? He's standing *over there*." In the first sentence, the speaker is referring to an image in the LCD; in the second, to Uncle John's physical location in the room. When the temporal dimension is involved, the complexities are magnified. Consider this type of adult statement, made while watching playback: "*Now* we are seeing Uncle John as he was *then*." (See also Matthews, 2005.)

This does not mean, of course, that learning about the video camera disadvantages children in their language learning—perhaps quite the reverse. Often, the children found these ambiguities amusing. Perhaps akin to the situation of children who learn two languages, in discussing the video camera, these Singaporean children's attention was focused even more precisely and deeply on the meanings of words, their arbitrariness and the relational nature of their meaning, and what has been termed the *dual function* of symbols and signs (Stetsenko, 1995; Vygotsky, 1966). In the present study, it may have been that discussion about the video camera strengthened understanding of deictic terms. Consider, for example, the association of the pointing function of deictic words with the pointing function of the video camera.

In fact, in the present study, we found that such potential confusion in communication between child and adult did not give rise to insurmountable problems. This was of interest to us because it implicated empathic and pragmatic dimensions of language and perhaps suggested that differentiating the representation from the represented is something basic to human consciousness. This would mean that, here, in these observations of children learning to use the video camera, this ability was being fine-tuned.

CHILDREN'S DEVELOPMENT IN MAKING MOVIES

At the start of this study, one that lasted 2 years, children's development in making movies had not been recorded. Now it has. Each different medium teases out slightly different aspects of the child's thinking. The insertion of the video camera into development reconfigures representational and expressive action assemblies. It encourages thinking in a particular way, in which line of sight, pointing, aiming, going-through, looking-through, and collinearity are coordinated.

It is also argued that children's expression and representation in any medium are driven and guided by deep patterns of meaning. Actions performed by the child on the video camera stem from deep concerns or deep interests that show up in her or his use and organization of other media. These interests are location, movement, shape, and form. These, in turn, implicate abiding interests in, and emergent concepts of, time, memory, personal history, and identity.

Perhaps of particular interest is how this might modify what we understand by egocentricity and the growth of decentration or what is sometimes referred to (significantly) as *perspective taking* (Borke, 1983; Cox, 1991; Donaldson, 1978; Piaget, 1959/2002).

This study suggests that there exist deep structures of representation and expression but that these manifest themselves differently according to the affordances of the particular medium (Gibson, 1979). The deep patterns of meaning that I describe as organizing and guiding child's drawing are both deeper and more abstract than I originally thought. Additionally, these developmental pathways run through metaphorical landscapes along which adult and child are fellow travelers. There is not the space here to describe the subtleties of the principles that allow the child into systems of metaphors of which the adult companion is an only partially conscious operator (Atkinson, 2003; Matthews, 2004).

Thelen and Smith (1998) noted that for emergent concepts to be formed, the child needs to repeatedly make different "takes" (p. 191) on the same event, until the attractors involved overlap and converge to become an understanding. Because the medium of videography allows (to adopt this same movie terminology) different takes of the same event, it may help a child appreciate an extraordinary fact about being a conscious, thinking, feeling agent in the world. This is the understanding that her or his viewpoint is at one and the same time both unprivileged yet unique.

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